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Distribution of Atlantic mackerel in ICNAF Subarea 5 and Statistical Area 6 based on research vessel spring trawl surveys, 1968-1975

by

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Introduction

Atlantic mackerel (*Scomber scombrus)* overwinter in deep water along the edge of the continental shelf in ICNAF Subarea 5 and Statistical Area 6 (SA 5-6) before beginning their annual northerly migration in the spring (Sette, 1950). During December-April, mackerel are most heavily concentrated and easily harvested as evidenced by commercial catches (Anderson, 1975a; Moores et al., 1975). It is also during this time that the probability is likely greatest for achieving the largest catches of mackerel in research vessel trawl surveys and for determining the most reliable estimates of abundance.

Estimates of relative stock abundance and the strength of recruiting year-classes, obtained independently of commercial fishery statistics by means of research vessel trawl surveys, are essential for adequate and reliable assessments of the mackerel stock in the Northwest Atlantic. Catch per tow indices of mackerel from United States (US) spring and autumn bottom trawl surveys in SA 5-6 have been reported by Anderson (1973, 1974, 1975b, 1976a). Estimates of recruitment based on US spring survey catches are presented by Anderson (1976b).

Spring bottom trawl surveys have been conducted by the US annually since 1968. Since 1973, additional spring bottom trawl surveys, intended primarily for determining recruitment estimates for herring (*Clupea harengus*), have been conducted by vessels from the Federal Republic of Germany (FRG), the German Democratic Republic (GDR), Poland, and the Union of Soviet Socialist Republics (USSR) (Dornheim, 1973; Anderson and Dornheim, 1974; Yudanov et al., 1974; Anthony et al., 1975; Hennemuth, 1975).

The purpose of this paper is to summarize the distribution of mackerel catches from past spring surveys. This is necessary to evaluate the data obtained from these surveys and in planning future surveys.

Materials and Methods

The US spring surveys (*ALBATROSS IV* and *DELAWARE II*) were based on a stratified random sampling design according to depth and area (Figure 1). A No. 36 Yankee bottom trawl was used during 1968-1972 and a larger high-opening No. 41 Yankee trawl was used during 1973-1975 (Grosslein, 1974). The area of coverage extended from Nova Scotia to Cape Hatteras with dates of sampling ranging between March 4 and May 16 (Table 1). Tows were made at a speed of 3.5 knots for 30 minutes with operations conducted 24 hours per day.

Additional spring surveys were made by the *WALTHER HERWIG* (FRG) in 1973-1975, the *KHRONOMETER* (USSR) in 1974, the *ERNST HAECKEL* (GDR) in 1975, and the *WIECZNO* (Poland) in 1975 (Table 1). These surveys were also based on the US stratified random sampling design (except for the 1973 *WALTHER HERWIG* survey), employed commercial herring bottom trawls, and covered selected strata between Nova Scotia and Cape Hatteras. Tows of 30 minutes duration were made at speeds ranging from 4.0 to 5.0 knots. Sampling was conducted 24 hours per day during the *KHRONOMETER* survey but only in daylight hours during the other surveys.

Catches of mackerel (in numbers) were plotted by station for each survey (Figures 2-15). The locations of null catches were also plotted to illustrate the sampling area. The numbers caught per tow at age 1, age 2, and age 3+ were also plotted separately (not illustrated in this paper) to determine if different distribution patterns existed for those age groups.

Results

Catches of mackerel during US spring surveys (Figures 2-6, 8, 10, 15) ranged primarily from the slope waters of Georges Bank to Cape Hatteras. A few mackerel were taken along the edge of the Scotian Shelf and in 1974 (Figure 10) and 1975 (Figure 15) from waters north of Georges Bank. Catches occurred generally in depths greater than 50 meters with many at 100-200 meters.

There was a progressively northeasterly shift in US survey mackerel catches from 1968 to 1975. In 1968 (Figure 2) and 1969 (Figure 3), most of the mackerel were caught in strata south of Delaware Bay (Divisions 6B and 6C). In 1970 (Figure 4) and 1971 (Figure 5), the catches shifted north to Divisions 6B and 6A. The 1972 (Figure 6) and 1973 (Figure 8) catches were mainly from Division 6A and Subdivision 5Zw, with considerable numbers taken on Georges Bank in 1973. In 1974 (Figure 10) and particularly in 1975 (Figure 15), Subdivision 5Ze (Georges Bank area) contained the majority of the mackerel catches.

Mackerel catches during the other spring surveys (Figures 7, 9, 11-14) generally were obtained in the same areas as during the US surveys, but were greater as the result of towing faster with larger trawls (Table 1). However, since the other surveys were limited to only portions of the total area sampled by the US, results were generally useful only in defining depth distribution but not the geographic range.

The 1973 *WALTHER HERWIG* survey (Figure 7) extended from the Gulf of Maine to Cape Hatteras, but mackerel catches were few and small in number mainly because very few stations were occupied in deep water where mackerel are generally located in the spring. The 1974 *WALTHER HERWIG* survey (Figure 9), limited primarily to the Nantucket Shoals-Georges Bank area, had nearly all of its mackerel catches in strata 10-15 and in water deeper than 100 meters. The 1975 *WALTHER HERWIG* survey (Figure 12) was extended westward to include all of Subdivision 5Zw. Most of the mackerel catches were from strata 6 and 13 where depths ranged from 56 to 110 meters.

The *KHRONOMETER* survey in 1974 (Figure 11), which extended from Maryland (Division 6B) to Nantucket Shoals, had good mackerel catches throughout the entire area both inshore and offshore. Distribution of catches agreed very closely with those obtained during the US survey that year (Figure 10).

The 1975 surveys conducted by the *ERNST HAECKEL* (Figure 13) and the *WIECZNO* (Figure 14) sampled strata 9, 10, and 13 and 1-12, respectively. The *ERNST HAECKEL* caught mackerel at nearly every station in strata 10 and 13 while the *WIECZNO* encountered mackerel throughout most of the area sampled.

Plotting the catches by age (not illustrated) indicated no discernible patterns of distribution by age. Age 1 or 2 mackerel were not necessarily found in depths shallower than age 3+ mackerel. Analysis did indicate, however, that at stations where substantial numbers of age 1 mackerel were caught, age 3+ mackerel were generally not present. Age 2 mackerel were commonly found either with age 1 or with age 3+ mackerel, but rarely with both at the same station, suggesting that age 1 mackerel may school discretely from age 3+ mackerel.

Discussion

Catches during spring surveys substantiate Sette's(1950) hypothesis that mackerel overwinter along the edge of the continental shelf primarily from Georges Bank to Cape Hatteras. Catches taken in the shallowest sampling strata (27-55 meters) in the Middle Atlantic-southern New England area suggest also that spawning activity had generally begun at the time of the spring surveys. Sette (1943) reported that spawning occurs as far as 80 miles to sea but mostly 10-30 miles from shore.

Comparison of the location of mackerel catches in US spring surveys from 1968 to 1975 indicated a pronounced northeasterly shift in their geographic distribution from the Middle Atlantic area to the southern New England-Georges Bank area. This shift was evident from the extensive coverage of the US surveys from Nova Scotia to Cape Hatteras. The apparent shift in the overwintering grounds may have been in response to changing environmental conditions. Available evidence including some observations of increased water temperature during the period of these surveys suggests that a general warming trend may be in process. The other spring surveys were not initiated until 1973, by which time the northeasterly shift in distribution was already apparent from the US surveys. Furthermore, the sampling area covered by the special surveys was insufficient to detect gross changes in distribution.

Another difficulty associated with the non-US spring surveys is that they were intended primarily for the purpose of sampling juvenile herring in order to obtain estimates of incoming year-class strength. Anthony et al. (1975) showed that juvenile herring are generally found in water less than 60 meters in southern New England and less than 80 meters on Georges Bank. Mackerel tend to be found in waters deeper than where juvenile herring occur. Examination of survey catches of the two species suggests that their distributions abut one another but do not overlap significantly. Consequently, a survey designed to sample only in areas of likely juvenile herring aggregations would tend to miss the areas of principal mackerel abundance.

Although the US survey catches of mackerel have been smaller than those obtained from the other spring surveys, the indices of mackerel year-class abundance at ages 1 and 2 and overall mackerel abundance as determined from the US spring surveys agree well with year-class abundance calculated from virtual population analysis (Anderson, 1976b) and with other estimates of overall abundance determined from commercial fishery statistics (Anderson, 1976a). The US surveys are the only surveys that have covered the regions of mackerel concentration each year. Furthermore, the US time-series beginning in 1968 also affords a year-to-year comparison of abundance indices not available from any of the other surveys. Although the *WALTHER HERWIG* surveys have been conducted since 1973, the same area has not been sampled each year. The non-US surveys have been extremely useful, however, because they have generally substantiated the results of the US surveys (e.g. relative abundance and age composition in selected strata) and have provided samples for estimating the age structure of the stock.

In conclusion, the US spring surveys, by virtue of the time-series available and the broad area of coverage, provide annually a satisfactory description of the geographic distribution of overwintering mackerel in SA 5-6. Analysis of survey catch data also suggests that the US surveys have provided sufficient information for measuring changes in relative abundance (Anderson, 1976a) and estimating the strength of recruiting year-classes (Anderson, 1976b). The other spring surveys conducted since 1973 have been valuable in providing data which support the US survey results such as defining certain areas of prime concentration, describing the age composition of the stock, and, in the case of the FRG surveys, measuring changes in relative abundance from year to year, although over a much shorter time-span than the US surveys. In the design of spring surveys which would be suitable for estimating the abundance and distribution of mackerel, it is important that the entire overwintering range from Georges Bank to Cape Hatteras be sampled to account for possible shifts in distribution such as occurred during 1968-1975.

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Table 1. Spring bottom trawl surveys conducted in ICNAF SA 5-6, 1968-1975.

Country	Vessel	Date	Area	Trawl	Speed (knots)
US	*ALBATROSS IV*	March 4-May 16,1968	Nova Scotia to Cape Hatteras	No. 36 Yankee	3.5
US	*ALBATROSS IV*	March 5-April 10, 1969	Nova Scotia to Cape Hatteras	No. 36 Yankee	3.5
US	*ALBATROSS IV*	March 12-April 29, 1970	Nova Scotia to Cape Hatteras	No. 36 Yankee	3.5
US	*ALBATROSS IV*	March 9-May 1, 1971	Nova Scotia to Cape Hatteras	No. 36 Yankee	3.5
US	*ALBATROSS IV*	March 8-April 24, 1972	Nova Scotia to Cape Hatteras	No. 36 Yankee	3.5
FRG	*WALTHER HERWIG*	Feb. 26-March 15, 1973	Gulf of Maine to Cape Hatteras	180-ft. herring	5.0
US	*ALBATROSS IV* and *DELWARE II*	March 16-May 15, 1973	Nova Scotia to Cape Hatteras	No. 41 Yankee	3.5
FRG	*WALTHER HERWIG*	March 19-April 3, 1974	Nantucket Shoals to Browns Bank	180-ft. herring	5.0
US	*ALBATROSS IV*	March 12-May 4, 1974	Nova Scotia to Cape Hatteras	No. 41 Yankee	3.5
USSR	*KHRONOMETER*	March 22-April 16, 1974	Cape Cod to Maryland	Hake 815	4.0
FRG	*WALTHER HERWIG*	March 11-March 26, 1975	So. New England to Browns Bank	180-ft. herring	4.0
GDR	*ERNST HAECKEL*	March 11-March 17, 1975	Nantucket Shoals to Georges Bank	160-ft. herring	4.2
Poland	*WIECZNO*	March 2-March 16, 1975	Southern New England	90-ft. herring	4.0
US	*ALBATROSS IV*	March 4-May 12, 1975	Nova Scotia to Cape Hatteras	No. 41 Yankee	3.5

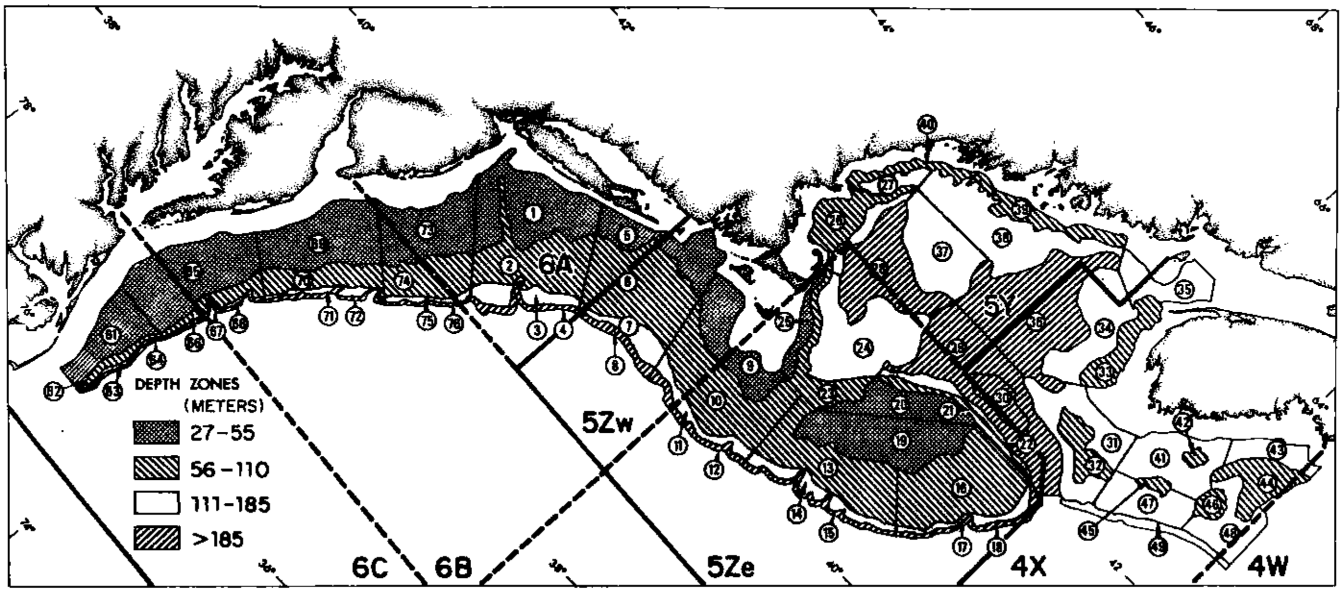

Fig. 1. US bottom trawl survey sampling strata in ICNAF SA 5-6.

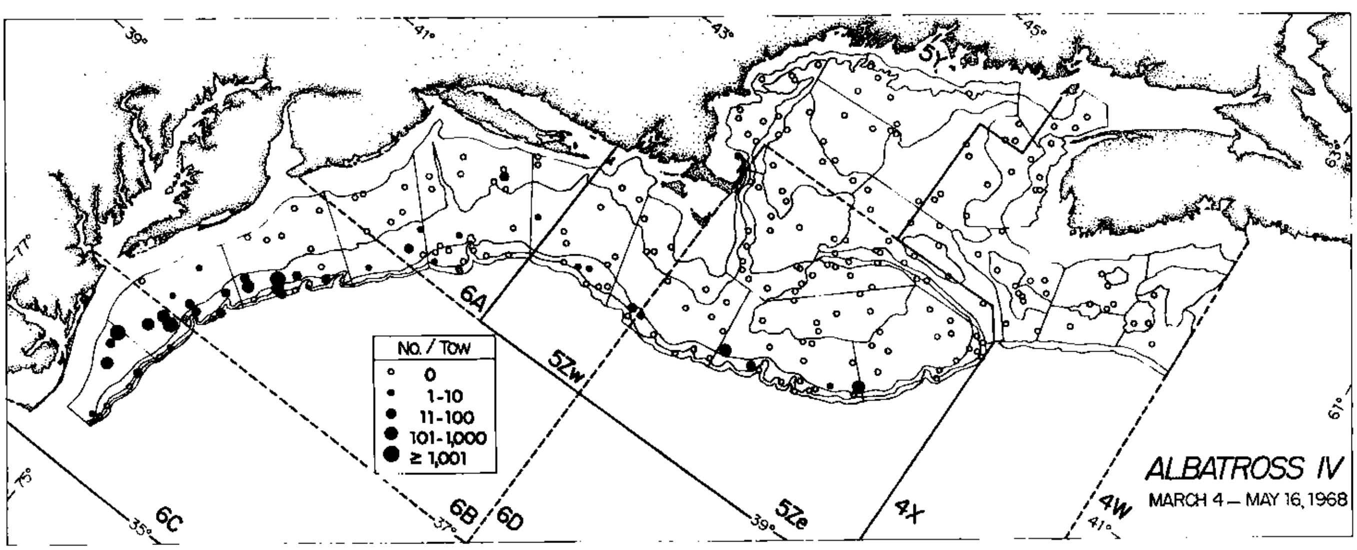

Fig. 2. Distribution of mackerel catches (no./tow) during the 1968 US spring survey.

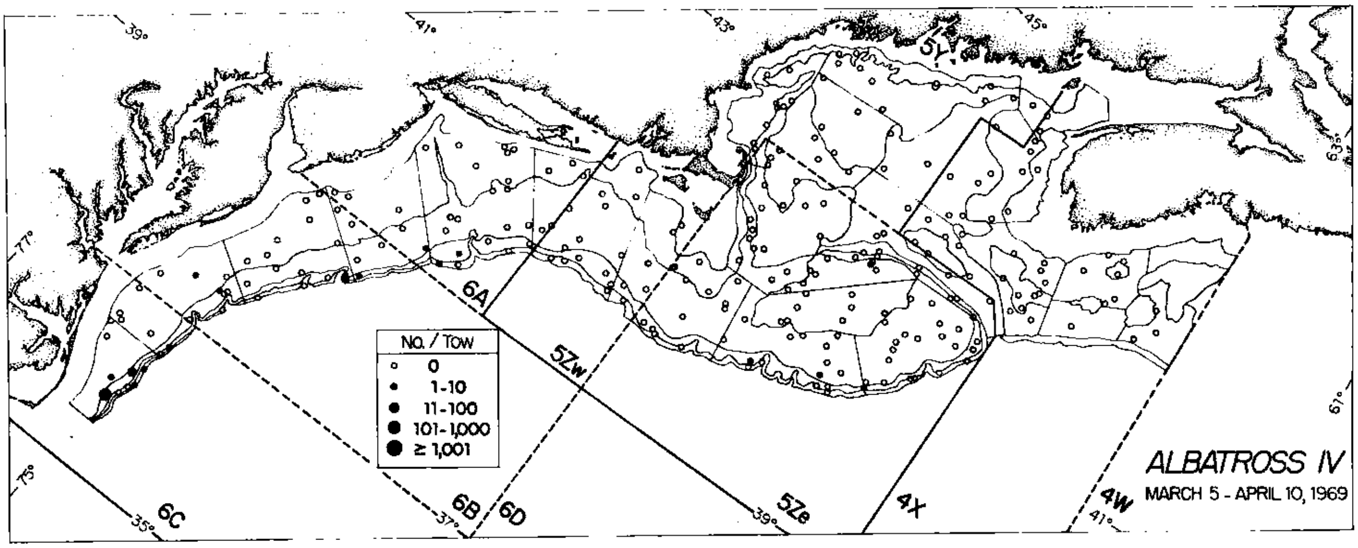

Fig. 3. Distribution of mackerel catches (no./tow) during the 1969 US spring survey.

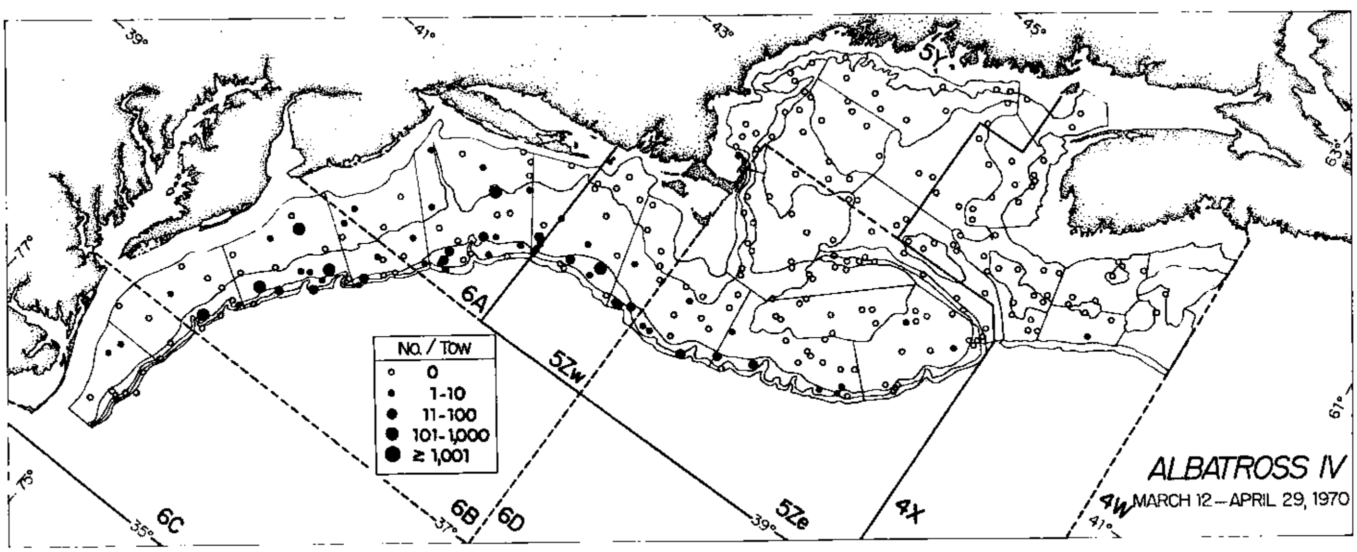

Fig. 4. Distribution of mackerel catches (no./tow) during the 1970 US spring survey.

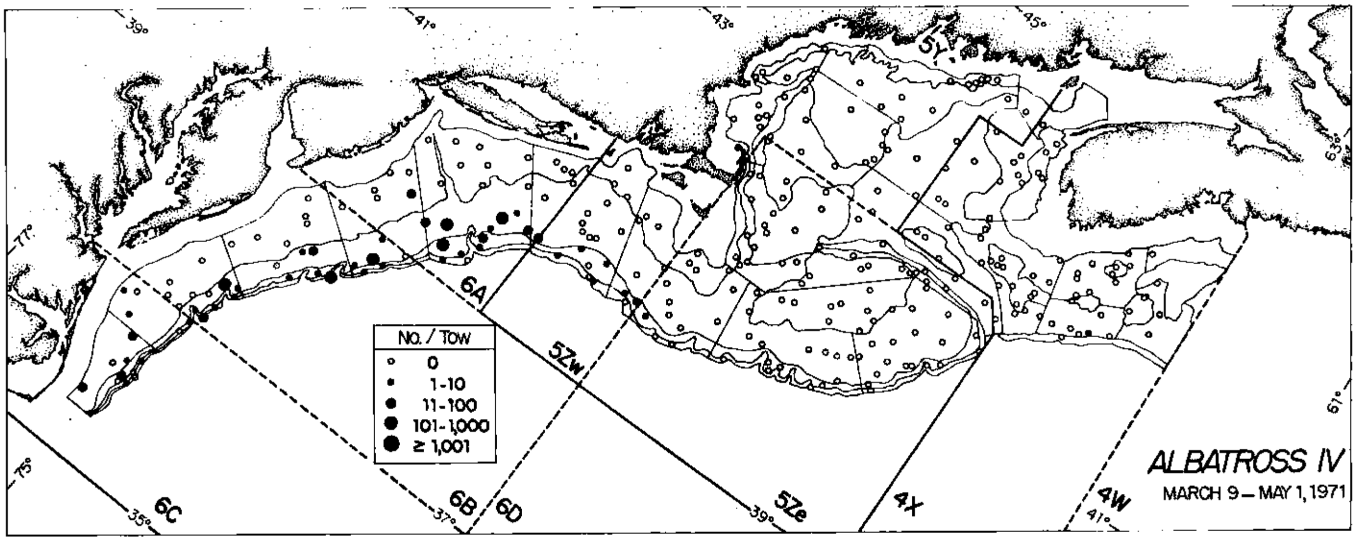

Fig. 5. Distribution of mackerel catches (no./tow) during the 1971 US spring survey.

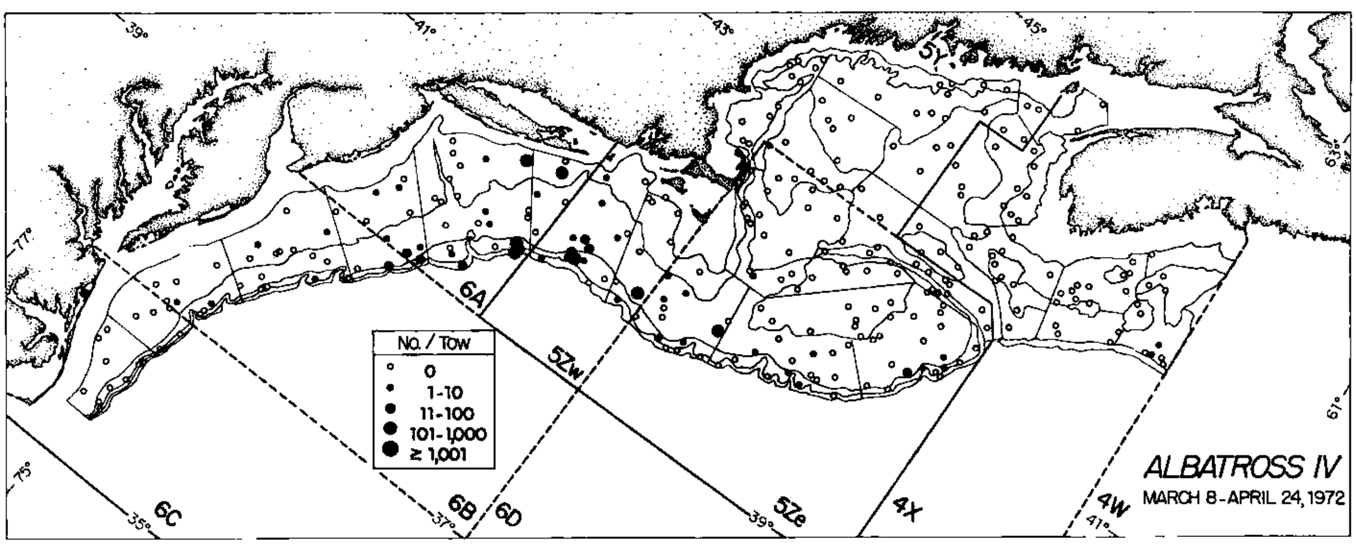

Fig. 6. Distribution of mackerel catches (no./tow) during the 1972 US spring survey.

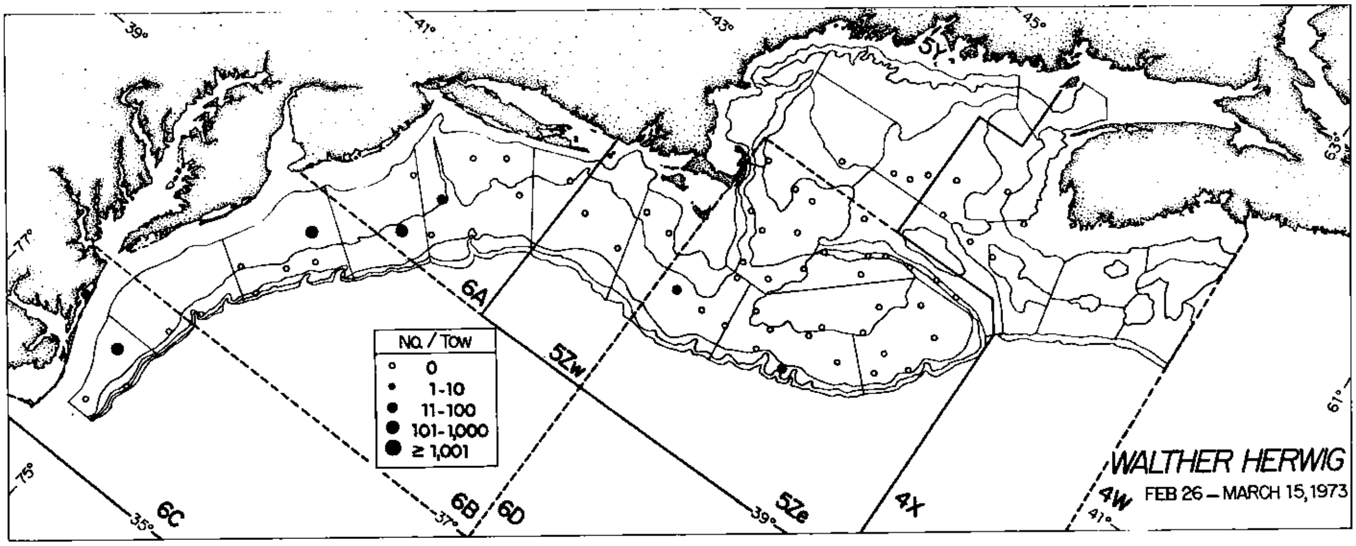

Fig. 7. Distribution of mackerel catches (no./tow) during the 1973 FRG spring survey.

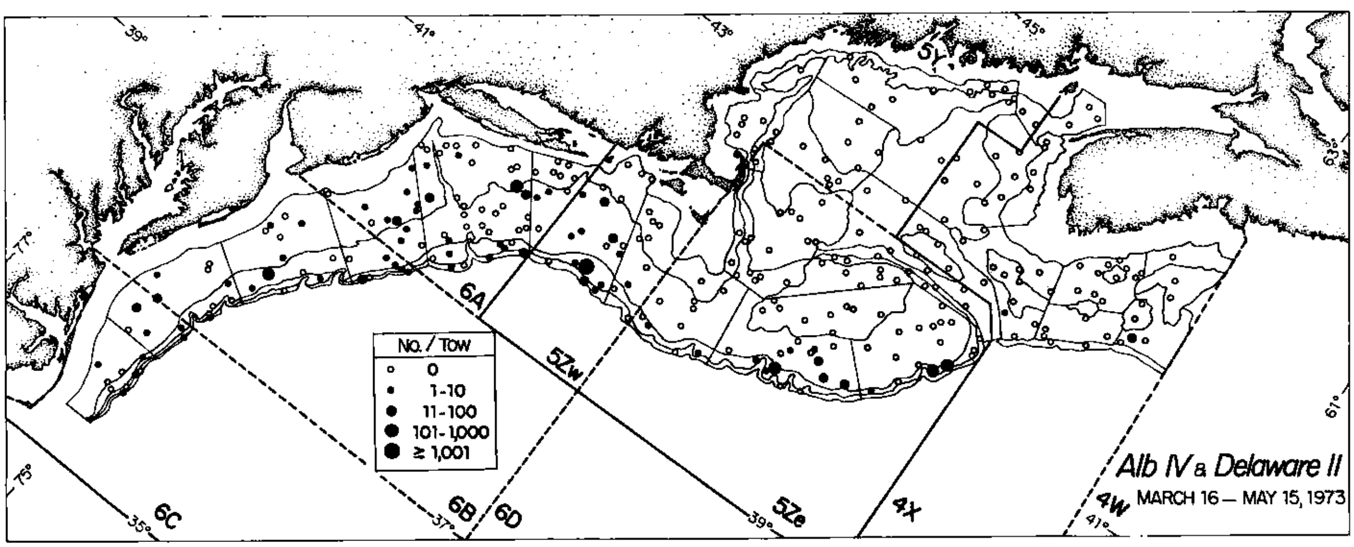

Fig. 8. Distribution of mackerel catches (no./tow) during the 1973 US spring survey.

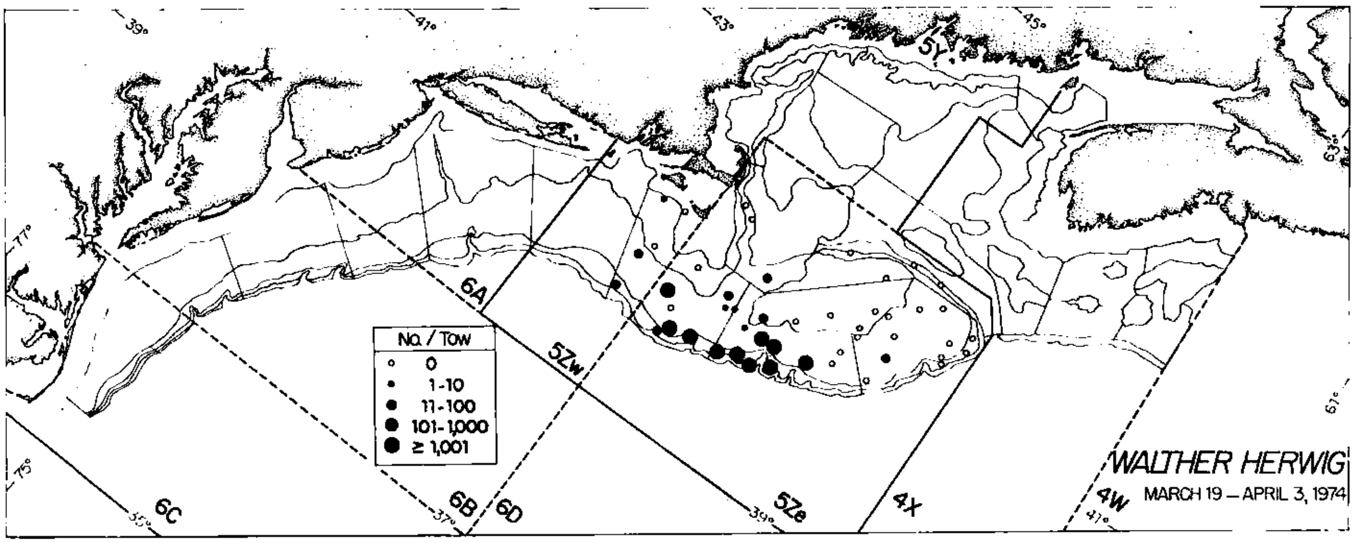

Fig. 9. Distribution of mackerel catches (no./tow) during the 1974 FRG spring survey.

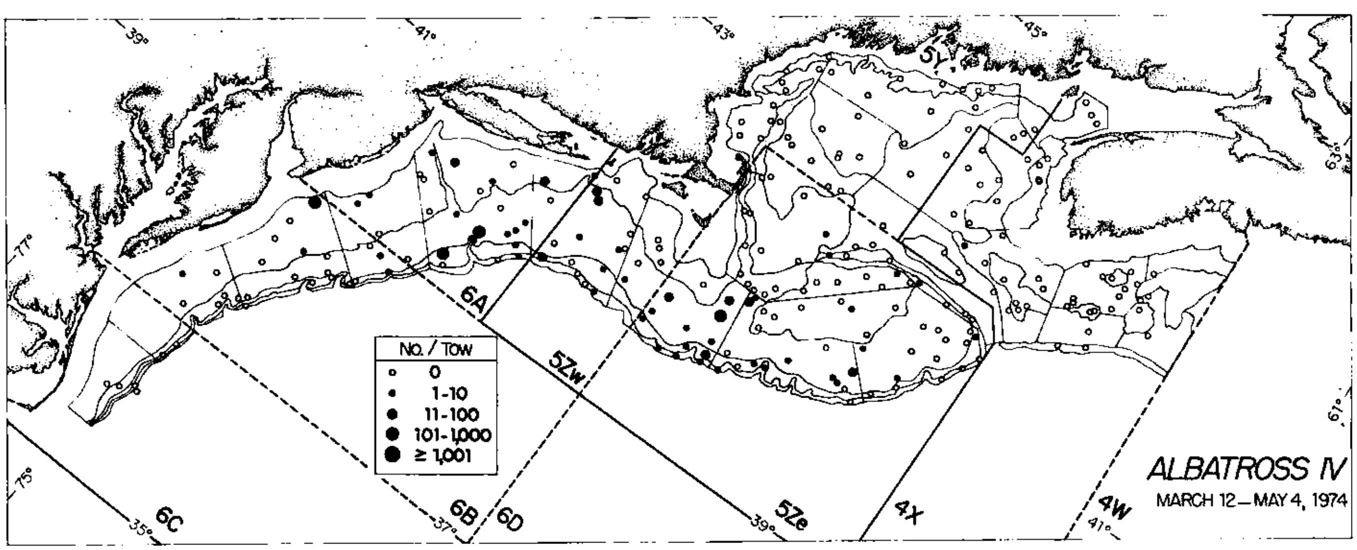

Fig. 10. Distribution of mackerel catches (no./tow) during the 1974 US spring survey.

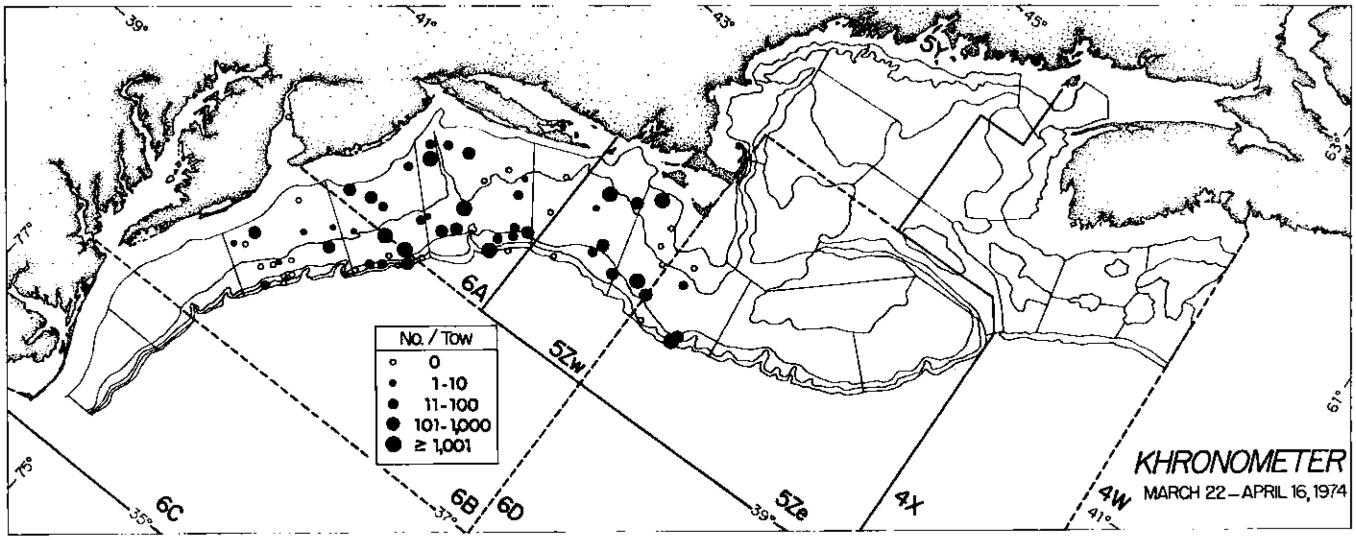

Fig. 11. Distribution of mackerel catches (no./tow) during the 1974 USSR spring survey.

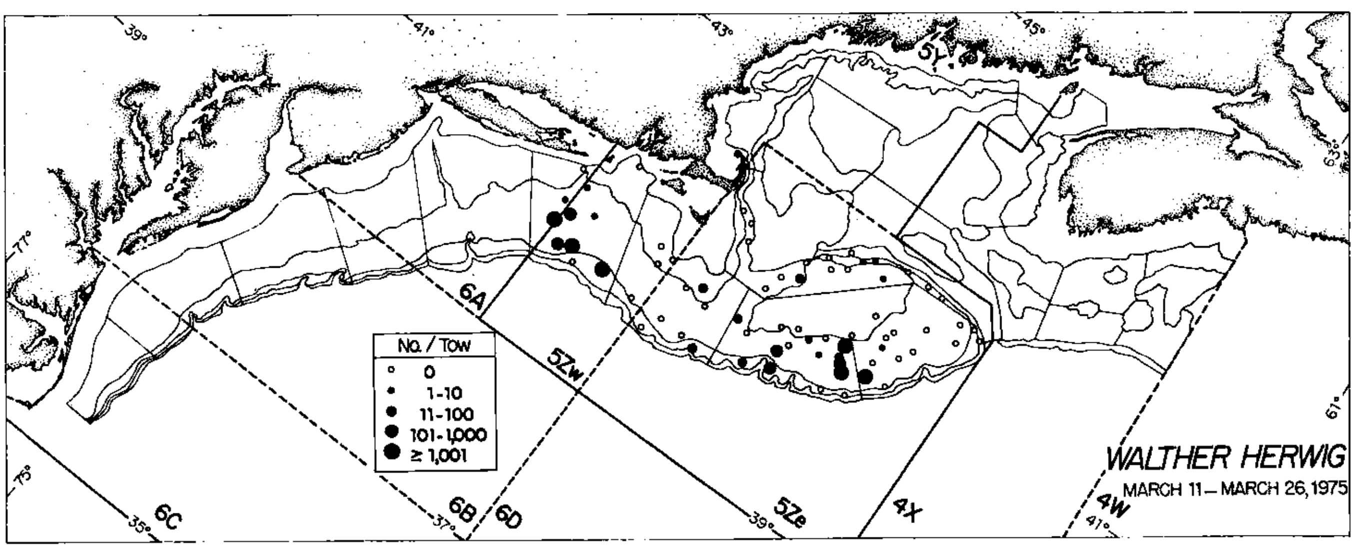

Fig. 12. Distribution of mackerel catches (no./tow) during the 1975 FRG spring survey.

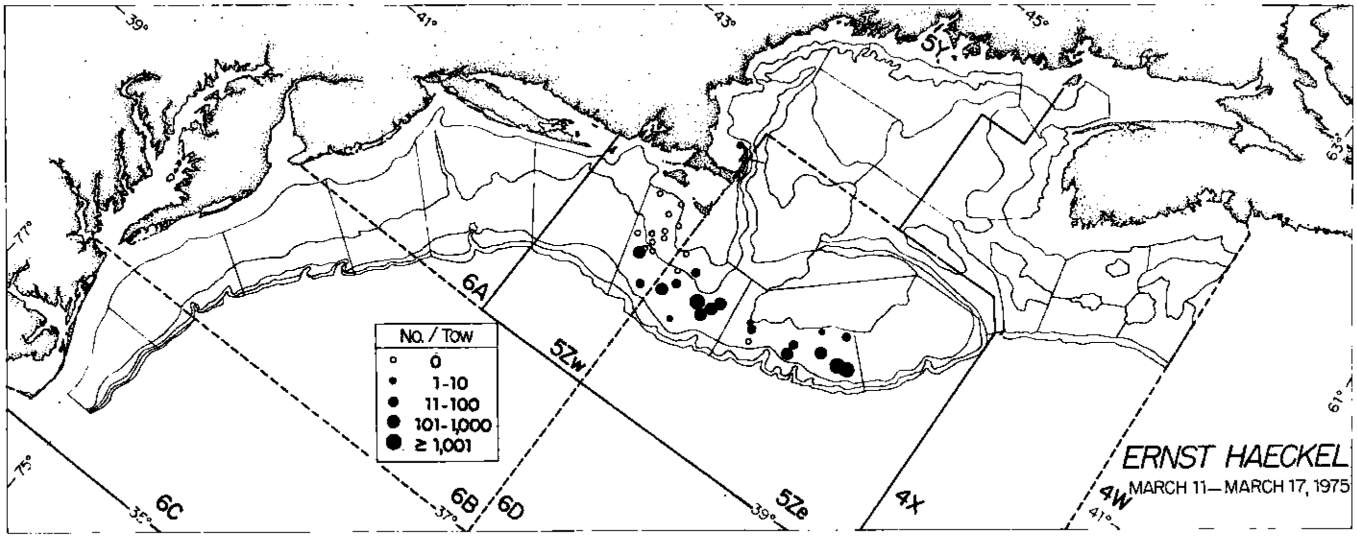

Fig. 13. Distribution of mackerel catches (no./tow) during the 1975 GDR spring survey.

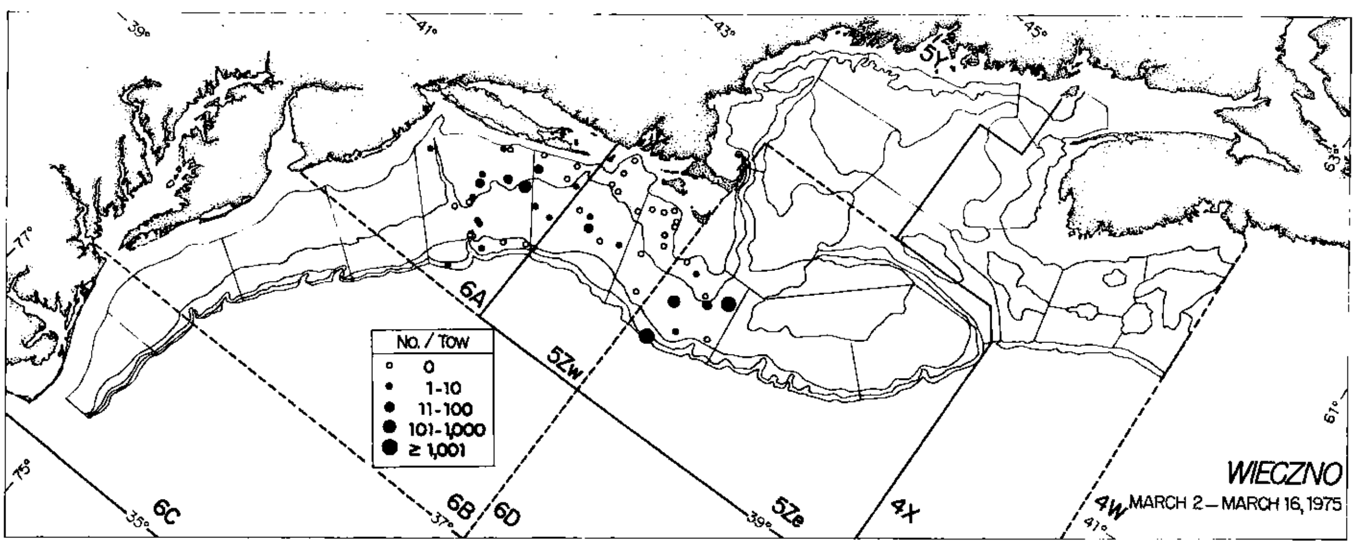

Fig. 14. Distribution of mackerel catches (no./tow) during the 1975 Polish spring survey.

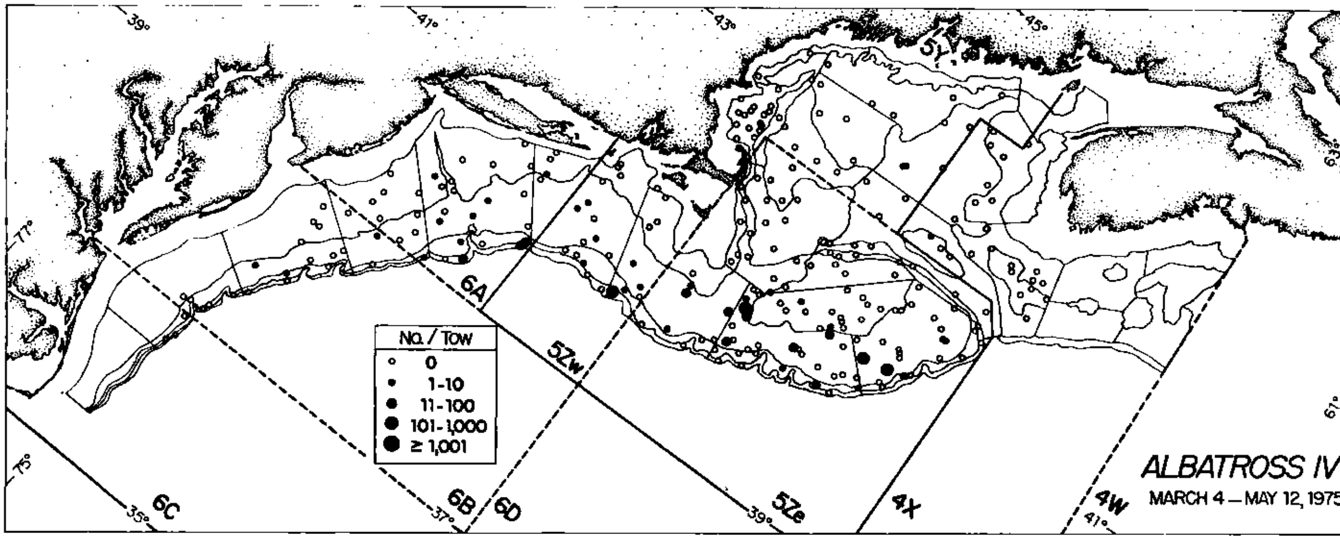

Fig. 15. Distribution of mackerel catches (no./tow) during the 1975 US spring survey.